Claims

1. A wavelength conversion element comprising:

a holder; and

plural prismatic ferroelectric single crystals disposed in said holder,

wherein,

said plural prismatic ferroelectric single crystals have at least five planes;

aspect ratios of planes perpendicular to respective longitudinal directions of said plural prismatic ferroelectric single crystals are virtually unity;

each of said plural prismatic ferroelectric single crystals has a domain inversion structure with a predetermined period in a direction perpendicular to the polarization direction thereof; and

said plural prismatic ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of other crystals.

2. The wavelength conversion element according to claim 1, wherein, when each of said plural prismatic ferroelectric single crystals converts a first light having a wavelength λ_1 into a second light having a wavelength λ_2 and a third light having a wavelength λ_3, said predetermined period is a period that enables quasi-phase-matching of the lights, so that said wavelength λ_1, said wavelength λ_2 and said

wavelength λ_3 satisfy the relation $1/\lambda_1 = 1/\lambda_2 + 1/\lambda_3$, and the relations $\lambda_1<\lambda_2$ and $\lambda_1<\lambda_3$.

3. The wavelength conversion element according to claim 1, wherein, when each of said plural prismatic ferroelectric single crystals converts a first light having a wavelength λ_1 into a second light having a wavelength λ_2, said predetermined period is a period that enables quasi-phase-matching of the lights, so that said first wavelength λ_1 and said second wavelength λ_2 satisfy the relation $\lambda_1 = 2\times\lambda_2$.

4. The wavelength conversion element according to claim 1, wherein, when each of said plural prismatic ferroelectric single crystals converts a first light having a wavelength λ_1 and a second light having a wavelength λ_2 into a third light having a wavelength λ_3, said predetermined period is the period that enables quasi-phase-matching of the lights, so that said first wavelength λ_1, said second wavelength λ_2 and said wavelength λ_3 satisfy the relation $1/\lambda_1 \pm 1/\lambda_2 = 1/\lambda_3$.

5. The wavelength conversion element according to claim 1, wherein each of said plural prismatic ferroelectric single crystals has six planes.

6. The wavelength conversion element according to claim 1,

wherein each of said plural prismatic ferroelectric single crystals is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

7. The wavelength conversion element according to claim 1, wherein said holder is made of heat-conductive material.

8. The wavelength conversion element according to claim 1, further comprising

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

9. The wavelength conversion element according to claim 8, further comprising a control unit for controlling said temperature control element.

10. The wavelength conversion element according to claim 1, wherein said plural prismatic ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive

material.

11. A light generating apparatus comprising:

a light source for emitting a first light having a first wavelength λ_1;

a wavelength conversion element for converting said first light into a second light having a second wavelength λ_2 and a third light having a third wavelength λ_3; and

a control unit for controlling the position of said wavelength conversion element,

wherein, said wavelength conversion element comprises a holder and plural prismatic ferroelectric single crystals disposed in said holder; said plural prismatic ferroelectric single crystals have at least five planes; aspect ratios of planes perpendicular to respective longitudinal directions of said plural prismatic ferroelectric single crystals are virtually unity; each of said plural prismatic ferroelectric single crystals has a domain inversion structure with a predetermined period enabling quasi-phase-matching in the direction perpendicular to the polarization direction thereof so that the first wavelength λ_1, the second wavelength λ_2, and the third wavelength λ_3 satisfy the relation $1/\lambda_1 = 1/\lambda_2 + 1/\lambda_3$ and the relations $\lambda_1 < \lambda_2$ and $\lambda_1 < \lambda_3$; and, said plural prismatic ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of the other

crystals.

12. The light generating apparatus according to claim 11, wherein each of said plural prismatic ferroelectric single crystals has six planes.

13. The light generating apparatus according to claim 11, wherein each of said plural prismatic ferroelectric single crystals is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

14. The light generating apparatus according to claim 11, wherein said holder is made of heat-conductive material.

15. The light generating apparatus according to claim 11, wherein said wavelength conversion element further comprises:

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

16. The light generating apparatus according to claim 15, wherein said control unit further controls the temperature of said temperature control element.

17. The light generating apparatus according to claim 11, wherein said plural prismatic ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive material.

18. A light generating apparatus comprising:

a light source for emitting a first light having a first wavelength λ_1;

a wavelength conversion element for converting said first light into a second light having a second wavelength λ_2; and

a control unit for controlling the position of said wavelength conversion element,

wherein, said wavelength conversion element comprises a holder and plural prismatic ferroelectric single crystals disposed in said holder; said plural prismatic ferroelectric single crystals have at least five planes; aspect ratios of planes perpendicular to respective longitudinal directions of said plural prismatic ferroelectric single crystals are virtually unity; each of said plural prismatic ferroelectric single crystals has a domain inversion structure with a predetermined period enabling quasi-phase-matching in the direction

perpendicular to the polarization direction thereof so that the first wavelength λ_1 and the second wavelength λ_2 satisfy the relation $\lambda_1 = 2\times\lambda_2$; and, said plural prismatic ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of the other crystals.

19. The light generating apparatus according to claim 18, wherein each of said plural prismatic ferroelectric single crystals has six planes.

20. The light generating apparatus according to claim 18, wherein each of said plural prismatic ferroelectric single crystals is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

21. The light generating apparatus according to claim 18, wherein said holder is made of heat-conductive material.

22. The light generating apparatus according to claim 18, wherein said wavelength conversion element further comprises:

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

23. The light generating apparatus according to claim 22, wherein said control unit further controls the temperature of said temperature control element.

24. The light generating apparatus according to claim 18, wherein said plural prismatic ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive material.

25. A light generating apparatus comprising:

a first light source for emitting a first light having a first wavelength λ_1;

an optical system for connecting said first light and a second light having a second wavelength λ_2 incident from outside;

a wavelength conversion element for converting said first light and said second light into a third light having a third wavelength λ_3; and

a control unit for controlling the position of said wavelength conversion element,

wherein, said wavelength conversion element comprises a holder and plural prismatic ferroelectric single crystals

disposed in said holder; said plural prismatic ferroelectric single crystals have at least five planes; aspect ratios of planes perpendicular to respective longitudinal directions of said plural prismatic ferroelectric single crystals are virtually unity; each of said plural prismatic ferroelectric single crystals has a domain inversion structure with a predetermined period enabling quasi-phase-matching in the direction perpendicular to the polarization direction thereof so that the first wavelength λ_1, the second wavelength λ_2 and the third wavelength λ_3 satisfy the relation $1/\lambda_1 \pm 1/\lambda_2 = 1/\lambda_3$; and said plural prismatic ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of the other crystals.

26. The light generating apparatus according to claim 25, wherein each of said plural prismatic ferroelectric single crystals has six planes.

27. The light generating apparatus according to claim 25, wherein each of said plural prismatic ferroelectric single crystals is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-

doped lithium tantalate with substantially stoichiometric composition.

28. The light generating apparatus according to claim 25, wherein said holder is made of heat-conductive material.

29. The light generating apparatus according to claim 25, wherein said wavelength conversion element further comprises:

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

30. The light generating apparatus according to claim 29, wherein said control unit further controls the temperature of said temperature control element.

31. The light generating apparatus according to claim 25, wherein said plural prismatic ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive material.

32. A wavelength conversion element comprising a cylindrical ferroelectric single crystal with a virtually completely round cross-section, wherein said cylindrical ferroelectric single crystal has a domain inversion

structure with a predetermined period in a direction perpendicular to said polarization direction.

33. The wavelength conversion element according to claim 32, wherein said cylindrical ferroelectric single crystal is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

34. The wavelength conversion element according to claim 32, wherein, when said cylindrical ferroelectric single crystal converts a first light having a first wavelength λ_1 into a second light having a second wavelength λ_2 and a third light having a third wavelength λ_3, said predetermined period is the period that enables quasi-phase-matching of the lights, so that said first wavelength λ_1, said second wavelength λ_2 and said third wavelength λ_3 satisfy the relation $1/\lambda_1 = 1/\lambda_2 + 1/\lambda_3$, and the relations $\lambda_1<\lambda_2$ and $\lambda_1<\lambda_3$.

35. The wavelength conversion element according to claim 32, wherein, when said cylindrical ferroelectric single crystal converts a first light having a first wavelength λ_1 into a second light having a second wavelength λ_2, said

predetermined period is the period that enables quasi-phase-matching of the lights, so that said first wavelength λ_1 and said second wavelength λ_2 satisfy the relation $\lambda_1 = 2\times\lambda_2$.

36. The wavelength conversion element according to claim 32, wherein, when said cylindrical ferroelectric single crystal converts a first light having a first wavelength λ_1 and a second light having a second wavelength λ_2 into a third light having a third wavelength λ_3, said predetermined period is the period that enables quasi-phase-matching of the lights, so that said first wavelength λ_1, said second wavelength λ_2 and said third wavelength λ_3 satisfy the relation $1/\lambda_1 \pm 1/\lambda_2 = 1/\lambda_3$.

37. A wavelength conversion element comprising:

a holder; and

plural cylindrical ferroelectric single crystals disposed in said holder,

wherein, respective cross-sections of said plural cylindrical ferroelectric single crystals are virtually completely round; each of said plural cylindrical ferroelectric single crystals has a domain inversion structure with a predetermined period in a direction perpendicular to said polarization direction; and said plural cylindrical ferroelectric single crystals are disposed in a way that said direction perpendicular to the

polarization direction of each crystal is the same as those of the other crystals.

38. The wavelength conversion element according to claim 37, wherein said plural cylindrical ferroelectric single crystals are selected respectively from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

39. The wavelength conversion element according to claim 37, wherein, when each of said plural cylindrical ferroelectric single crystals converts a first light having a first wavelength λ_1 into a second light having a second wavelength λ_2 and a third light having a third wavelength λ_3, said predetermined period is the period that enables quasi-phase-matching of the lights, so said first wavelength λ_1, said second wavelength λ_2 and said third wavelength λ_3 satisfy the relation $1/\lambda_1 = 1/\lambda_2 + 1/\lambda_3$, and the relations $\lambda_1<\lambda_2$ and $\lambda_1<\lambda_3$.

40. The wavelength conversion element according to claim 37, wherein, when each of said plural cylindrical ferroelectric single crystals converts a first light having

a first wavelength λ_1 into a second light having a second wavelength λ_2, said predetermined period is the period that enables quasi-phase-matching of the lights,so that said first wavelength λ_1 and said second wavelength λ_2 satisfy the relation $\lambda_1 = 2\times\lambda_2$.

41. The wavelength conversion element according to claim 37, wherein, when each of said plural cylindrical ferroelectric single crystals converts a first light having a first wavelength λ_1 and a second light having a second wavelength λ_2 into a third light having a third wavelength λ_3, said predetermined period is the period that enables quasi-phase-matching of the lights, so that said first wavelength λ_1, said second wavelength λ_2 and said third wavelength λ_3 satisfy the relation $1/\lambda_1 \pm 1/\lambda_2 = 1/\lambda_3$.

42. The wavelength conversion element according to claim 37, wherein said holder is made of heat-conductive material.

43. The wavelength conversion element according to claim 37, further comprising:

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

44. The wavelength conversion element according to claim

43, further comprising a control unit for controlling said temperature control element.

45. The wavelength conversion element according to claim 37, wherein said plural cylindrical ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive material.

46. A light generating apparatus comprising:

a light source for emitting a first light having a first wavelength λ_1;

a wavelength conversion element for converting said first light into a second light having a second wavelength λ_2 and a third light having a third wavelength λ_3; and

a control unit for controlling the position of said wavelength conversion element,

wherein, said wavelength conversion element comprises a holder and plural cylindrical ferroelectric single crystals disposed in said holder; respective cross-sections of said plural cylindrical ferroelectric single crystals are virtually completely round; each of said plural cylindrical ferroelectric single crystals has a domain inversion structure with a predetermined period enabling quasi-phase-matching of lights in the direction perpendicular to said polarization direction so that the first wavelength λ_1, the second wavelength λ_2 and the third wavelength λ_3 satisfy

the relation $1/\lambda_1 = 1/\lambda_2 + 1/\lambda_3$ and the relations $\lambda_1<\lambda_2$ and $\lambda_1<\lambda_3$; and said plural cylindrical ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of the other crystals.

47. The light generating apparatus according to claim 46, wherein said plural cylindrical ferroelectric single crystals are selected respectively from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

48. The light generating apparatus according to claim 46, wherein said holder is made of heat-conductive material.

49. The light generating apparatus according to claim 46, wherein said wavelength conversion element further comprises:

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

50. The light generating apparatus according to claim 49, wherein said control unit further controls the temperature of said temperature control element.

51. The light generating apparatus according to claim 46, wherein said plural cylindrical ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive material.

52. A light generating apparatus comprising:

a light source for emitting a first light having a first wavelength λ_1;

a wavelength conversion element for converting said first light into a second light having a second wavelength λ_2; and

a control unit for controlling the position of said wavelength conversion element,

wherein, said wavelength conversion element comprises a holder and plural cylindrical ferroelectric single crystals disposed in said holder; respective cross-sections of said plural cylindrical ferroelectric single crystals are virtually completely round; each of said plural cylindrical ferroelectric single crystals has a domain inversion structure with a predetermined period enabling quasi-phase-matching of the lights in the direction perpendicular to said polarization direction so that the first wavelength λ_1

and the second wavelength λ_2 satisfy the relation $\lambda_1 = 2\times\lambda_2$; and said plural cylindrical ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of the other crystals.

53. The light generating apparatus according to claim 52, wherein each of said plural cylindrical ferroelectric single crystals is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

54. The light generating apparatus according to claim 52, wherein said holder is made of heat-conductive material.

55. The light generating apparatus according to claim 52, wherein said wavelength conversion element further comprises:

a temperature control element disposed in said holder; and

a heat-insulating frame surrounding said holder and said temperature control element.

56. The light generating apparatus according to claim 55, wherein said control unit further controls the temperature of said temperature control element.

57. The light generating apparatus according to claim 52, wherein said plural cylindrical ferroelectric single crystals are disposed with spaces having predetermined width and said spaces are filled with heat-conductive material.

58. A light generating apparatus comprising:

a first light source for emitting a first light having a first wavelength λ_1;

an optical system for connecting said first light and a second light having a second wavelength λ_2 incident from outside;

a wavelength conversion element for converting said first light and said second light into a third light having a third wavelength λ_3; and

a control unit for controlling the position of said wavelength conversion element,

wherein, said wavelength conversion element comprises a holder and plural cylindrical ferroelectric single crystals disposed in said holder, and each cross-section of said plural cylindrical ferroelectric single crystals is virtually completely round; each of said plural cylindrical ferroelectric single crystals has a domain inversion

structure with a predetermined period enabling quasi-phase-matching in the direction perpendicular to said polarization direction so that the first wavelength λ_1, the second wavelength λ_2 and the third wavelength λ_3 satisfy the relation $1/\lambda_1 \pm 1/\lambda_2 = 1/\lambda_3$; and said plural cylindrical ferroelectric single crystals are disposed in a way that said direction perpendicular to the polarization direction of each crystal is the same as those of the other crystals.

59. The light generating apparatus according to claim 58, wherein each of said plural cylindrical ferroelectric single crystals is selected from a group comprising lithium niobate with substantially stoichiometric composition, lithium tantalate with substantially stoichiometric composition, impurity-doped lithium niobate with substantially stoichiometric composition, and impurity-doped lithium tantalate with substantially stoichiometric composition.

60. The light generating apparatus according to claim 58, wherein said holder is made of heat-conductive material.

61. The light generating apparatus according to claim 58, wherein said wavelength conversion element further comprises:

a temperature control element disposed in said holder;

and

a heat-insulating frame surrounding said holder and said temperature control element.

62. The light generating apparatus according to claim 61, wherein said control unit further controls the temperature of said temperature control element.

63. The light generating apparatus according to claim 58, wherein said plural cylindrical ferroelectric single crystals are disposed with spaces with predetermined width and said spaces are filled with heat-conductive material.